

PIG SENSOR ARRANGEMENT FOR HIGH VOLTAGE COATING SYSTEM

5

FIELD OF THE INVENTION

[00001] This invention relates to a sensor arrangement for a system used for series coatings of work pieces, such as automotive bodies, in which the coating material is conventionally charged to a high voltage and a pig or movable element is disposed in the delivery line or lines which receive conductive coatings, solvents, etc., and the sensor arrangement is utilized to sense the location of the pig or movable element.

BACKGROUND OF THE INVENTION

[00002] Electrostatic coating application systems for conductive coatings, such as water base paint, for mass production applications are known in the art. In a typical application, a series of work pieces, such as automotive bodies, are conveyed through a paint booth, wherein each work piece may be coated, for example, with a different color paint. In such applications, the coating apparatus typically includes a color changer, a rotary atomizer and a line connecting the color changer and the rotary atomizer, either directly or through a paint cannister. Following each application of coating or paint, the line or lines are generally purged with a solvent, typically ionized water for water base paint. However, similar systems may be utilized for powder coating materials. One means of transmitting the paint or solvent through the lines includes a movable member, such as a pig or pigging element, which is transmitted through the line or lines to either push the coating, separate one coating from another coating, or separate the coating from a solvent, etc. In paint application systems having one or more pigs or pigging elements, it is also

conventional to include one or more pig stations. For example, the coating delivery system may, for example, include a first pig station adjacent the color changer and a second pig station adjacent the applicator which is typically a rotary atomizer which imparts a high voltage to the coating. Where the coating delivery system includes an intermediate cannister, the coating delivery system may, for example, include four pig stations, including a first pig station adjacent the color changer, a second pig station adjacent the cannister inlet, a third pig station adjacent the cannister outlet and a fourth pig station adjacent the applicator.

[00003] As will be understood, in such coating application systems, it is necessary to determine the location of a movable element or pig in the system under high voltage conditions. For example, a valve may be opened to supply coating material or solvent to the line upon receipt of a pig in a pig receiver station. Typically, the pigs are moved or transferred back and forth between the pig stations. One method of locating a pig in a coating delivery system is to utilize a magnet or other magnetically acting transmitter element in the pig and utilize a magnet sensor in the pig station or adjacent the delivery line. However, where the coating is conductive and subject to high voltage, conventional sensing and actuator systems may not be accurate or require complicated hardware or software as set forth below. Other examples of movable members are the shaft of a metering pump, a rotary atomizer, etc. used in water base paint applications subject to high voltage.

[00004] In one disclosed embodiment, the position or movement of which needs to be determined within a section of such a paint application system that is connected to a high voltage, are pigs that can be moved back and forward between pig stations of a color supply line. For example, EP 0 319 172, DE 100 33 987 and DE 101 31 562 describe methods in which a high voltage is applied to the pig stations

on the atomizer side during the coating operation of the atomizer via the electrically conductive paint column. Special initiators with pneumatic switches are utilized for determining the pig positions in the lines and pig stations that are connected to a high voltage, wherein said pneumatic switches respond to magnets integrated into the pig
5 body and able to operate under a high voltage. However, a high space requirement and undesirably long reaction times need to be accepted in this case. Similar problems occur in other system sections as described below.

[00005] The invention is based on the objective of disclosing a sensor arrangement that makes it possible to determine the position or movement of a
10 moving member within a section of the coating system that is connected to a high voltage without delay and in a space-saving fashion. This objective is attained with the sensor arrangement of this invention.

SUMMARY OF THE INVENTION

15 [00006] The sensor for a coating delivery system of this invention includes a movable member, such as a pig, including a magnetically acting transmitter element, such as a permanent magnet, for signaling the position or movement of the movable member, and a sensor element responsive to the magnetically acting transmitter element in a portion of the delivery system subject to high voltage,
20 wherein the sensor element includes an optical polarization device subject to magneto-optical change upon approach of the magnet, generating a polarized light signal, and wherein the sensor includes optical fibers connected to the polarization device and wherein the polarization device is located in a section of the coating delivery system subject to high voltage. The optical fibers are connected to an
25 electronic device that is situated remotely from the high voltage region which

generates an electric signal that corresponds to the light signal received from the polarization device through the optical fibers. In the disclosed embodiment, the sensor element includes a reflector that reflects the light arriving the polarization device to an analyzer, wherein a refractive element or prism turns the polarized light
5 transmitted between the polarization device and the reflector.

[00007] The sensor element including the polarization device may be located adjacent a coating delivery line which transmits the movable element or pig or the sensor may be located in a pig station of the coating delivery system. The sensor element and the magnetically transmitting element may also be arranged in or on a
10 valve to determine the switching position of the valve that operates under high voltage and can be switched in a remote-controlled fashion, wherein the valve element can be displaced between two switching positions and releases the path for a medium flowing through the valve in one switching position, while the valve is blocked when the valve element is situated in the other switching position. In this case, the
15 magnetically transmitting element is arranged in a component that can be displaced with the valve element and the sensor element is arranged in or on a component of the valve that remains stationary relative to the valve element.

[00008] The magnetic-optic sensor systems to be used in accordance with the invention utilize, for example, the Faraday effect or, in other words, the
20 rotation of the polarization direction of linearly polarized light waves during the passage through an isotropic medium under the influence of a magnetic field. Alternatively, the sensor systems may also utilize the known magneto-optical Kerr effect. The magnetically acting transmitting element may consist of a permanent magnet or an element of iron, steel or another material with ferromagnetic properties
25 that makes it possible to change the magnetic field of a magnetic element situated or

encapsulated in the sensor system. Sensor systems of this type are available on the market for other purposes, e.g., in the form of position sensors for the rudders and elevators of airplanes, in which they are used as a replacement for the fly-by-wire technique (EP 0 319 172). When used in electrostatic coating systems, however, these

5 sensor systems have the surprising or unexpected advantage that they are easily able to operate under a high voltage. In comparison with pneumatic switches used for this purpose in electrostatic coating systems, in particular, as pig sensors, the sensor systems utilized in accordance with the invention have a smaller structural size and significantly shorter reaction times. These are particularly important aspects for an

10 automated control of the coating operation in modern series coating systems. These advantages are preferably attained without any active electric elements in the sensor which would require a battery under the given high voltage conditions and would have a correspondingly short service life. Other advantages of the magnetic-optic sensor system can be seen in the fact that it does not require any balancing and no

15 complicated software for the program control of the coating system.

BRIEF DESCRIPTION OF THE DRAWINGS

- [00009] Figure 1 is a side, partially cross-sectioned view of a fluid delivery line, a pigging element having a magnet and a sensor arrangement;
- 20 [00010] Figure 2 is a side cross-sectional view of a pig station including the sensor arrangement of this invention;
- [00011] Figure 3 is a pneumatic cylinder having the sensor arrangement of this invention; and
- [00012] Figure 4 is a metering pump for coating material having the
- 25 sensor arrangement of this invention.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

[00013] Figure 1 shows a paint line 10 that delivers an electrically conductive coating material, e.g., water base paint, to a (not-shown) electrostatic atomizer that charges the coating material situated in the paint line 10 to a high voltage. A pig 12 is moved backward and forward in the line 10 in order to transport the coating material and/or solvent to clean the line, wherein the movement of the pig past a certain location needs to be signaled to the control system. For this purpose, a magnetically acting transmitting element, e.g., a permanent magnet 14, is integrated or preferably encapsulated into the polymeric body of the pig, wherein a pig sensor 15 arranged at the concerned location responds to this transmitting element. The pig sensor 15 preferably consists of a relatively thin, long cylindrical housing that contains a (not-shown) polarization device that is connected to an arrangement 16 of two optical fibers, wherein one optical fiber transmits light to, for example, a diode and the other fiber transmits light signals generated by the sensor to an electronic device that is preferably situated remotely from the high-voltage region and serves for generating an electric signal that corresponds to the light signal. The polarizer linearly polarizes the received light. The polarized light is reflected by a mirror situated on the end face of the sensor housing. For example, the polarized light may be reflected to a polarization detector or analyzer by means of a refractive element (Faraday effect element) in accordance with Figure 15 of initially cited EP 0 319 172, the disclosure of which is incorporated herein by reference. This polarization detector or analyzer may form part of the polarization device and be connected to the output fiber on its opposite side. In the normal state, the polarized light reaches the output fiber in an unobstructed fashion. However, when the sensor is situated in the

magnetic field of the pig 12, the Faraday effect causes the linearly polarized light to be turned in dependence on the field intensity such that its path into the output fiber is blocked. The change in the light signal is evaluated by the remote electronic device. It would also be conceivable to utilize a sensor that operates in accordance with the magneto-optical Kerr effect and in which the polarization of light reflected on a magnetized ferromagnetic mirror is changed. In Figure 1, the polarized light is received and detected by a control which is connected to a valve "V" which controls the flow of fluid, such as solvent from a source to delivery line 10.

[00014] Magneto-optical sensors of the cylindrical shape shown are available on the market and have, for example, a diameter of approximately 3-8 mm and a length of 20 mm. An "Optical Speed Sensor" of the type described is available from TEIJIN SEIKI Co., Ltd. of Yokohama-Shi, Japan. The arrangement of optical fibers preferably is flexible such that it can be easily installed within the coating system.

[00015] The pig sensor 15 is arranged such that the longitudinal axis of its cylindrical housing extends transverse to the moving direction of the pig 12 and its end face faces the magnet 14. A similar pig sensor 15' may be additionally or alternatively arranged on the line 10 such that its longitudinal axis extends parallel to the moving direction.

[00016] Figure 2 shows a pig station 20 of a generally known coating system with scraped lines. For example, the pig line 10 (Figure 1) may be connected to the connection 21 of the pig station 20. Within the pig station, the pig 12 that contains the magnet 14 or other magnetically acting transmitter element is situated in an end position that is monitored and signaled by the pig sensor 25. The pig sensor 25

installed into the pig station may correspond to the above-described sensor 15 with respect to its shape, position and function.

[00017] One of the advantages of the described sensor system can be seen in the fact that it is not only suitable as a pig sensor, but can also be used on
5 other sections of the electrostatic coating system that may (but do not have to) be connected to a high voltage in a largely unaltered fashion. Figure 3 shows one example in the form of a pneumatic cylinder 30 as is, among other things, required as a pneumatic linear drive for a line disconnect coupling situated in the vicinity of the atomizer and for other sections of the coating system that are connected to a high
10 voltage. At least one (not-shown) magnet or other magnetically acting transmitter is arranged on the piston rod that can be displaced in the pneumatic cylinder, wherein one respective sensor 35 and 35' of the described type responds to the magnet or magnetically acting sending in both end positions of the piston. In the position shown, both sensors can be easily mounted on the pneumatic cylinder 30 parallel to
15 the moving direction of the piston by means of brackets 31, 31'.

[00018] Similar to the pneumatic cylinder shown, the piston end positions can also be monitored and signaled in piston metering cylinders that are connected to a high voltage and used in conventional coating systems for realizing a metered fluid delivery.

20 [00019] Figure 4 shows another example in the form of a gear pump or other metering pump 40 for the metered delivery of water base paint that can be charged to a high voltage by a proximal atomizer. The metering pump 40 is driven by a driving motor 41 via a shaft 42 of an insulating material and a clutch 47. In such metering pump arrangements, a fracture of the insulating shaft 42 or a clutch failure
25 may lead to the unnoticed stopping of the metering pump 40 while of the driving

motor 41 continues to rotate. In order to monitor the pump function, a magnetically acting transmitter element, e.g., a magnet 44, is directly mounted on the input shaft of the pump, for example, on a clutch element 48 that is seated on and rotates with the input shaft, wherein said transmitter responds to the sensor 45 of the above-described type which is stationarily arranged in the vicinity of the clutch element 48. When the pump comes to a stop, the light signal generated by the sensor 40 during normal operation due to the cyclic passage of the magnet 44 is correspondingly changed. Since the light signal also changes with the frequency of the polarization change in the sensor 45, this example, in particular, indicates that the described sensor system is also suitable for measuring the rotational speed of rotating parts in an electrostatic coating system that are connected to a high voltage. The signal evaluation or the measurement of the rotational speed may take place in the electronic device situated remotely from the high-voltage region.

[00020] Another not-shown example for utilizing the invention consists of the sensor element and the magnetically acting transmitter element forming collision protection elements for a machine of the electrostatic coating system which moves an electrostatic coating tool or other tool. In this case, one element is arranged in or on a stationary part of the machine and the other element is arranged in or on a part that moves relative to the stationary part during a collision of the tool. One typical example for this is the arrangement of the magnetically acting transmitting element on the mounting flange of an atomizer that, for example, is exchangeably mounted on a coating robot and moves relative to its mounting flange when it collides with the workpiece to be coated or another part of the system. In this case, the sensor is arranged on the mounting flange of the robot in the vicinity of the magnetically acting transmitting element, wherein one utilizes the change in the light signal that

occurs when the influence of the magnetic field on the sensor or the influence of the magnetic field in the sensor becomes weaker or disappears. The sensor system is particularly suitable for a collision protection device of the type described in DE 101 15 661, the disclosure of which is incorporated by reference. Similarly, the transmitting element may also be arranged in or on an electrostatic atomizer or another tool that is exchangeably mounted on a holding element of a motive machine of the coating system, wherein the sensor element is arranged in or on the holding element.

[00021] According to another example, the magnetically transmitting element may be arranged in or on a valve in order to determine the switching position of a valve as shown in Figure 1 that operates under a high voltage and can be switched in a remote-controlled fashion, wherein the movable valve element of said valve can be displaced between two switching positions and releases the path for a medium flowing through the valve in one switching position while said path is blocked when the valve element is situated in the other switching position. In this case, the magnetically transmitting element is arranged in a component that can be displaced with the valve element, and the sensor element is arranged in or on a component of the valve that remains stationary relative to the valve element. This may, in particular, pertain to the inquiry of the position of the master needle valve in an electrostatic atomizer described in DE 101 15 472, which is incorporated herein by reference.